

USPN 10/656,529

Applicants' docket #C-3053

### **CLAIM LISTING**

Claims 1-21 (cancelled)

- 1        22. (New) A method for operating a fuel cell system, the system including a stack of  
2        PEM fuel cells including at least one cooler for carrying antifreeze through the  
3        stack to remove heat, the fuel cell system further including a water circulation  
4        system for accumulating water and circulating that water through water flow  
5        passages passing through each cell, wherein, at the time of start-up, the stack has  
6        frozen water therein and there is insufficient liquid water within the water  
7        circulation system to enable the circulation of water, the method for operating the  
8        fuel cell system including (a) starting up and operating the frozen stack by  
9        introducing non-humidified reactants into the cells and connecting a load across  
10       the stack to generate heat to increase the stack temperature to above 0°C and  
11       thereby melt frozen water within the stack, including accumulating liquid water  
12       during stack operation until there is sufficient liquid water to enable circulation of  
13       liquid water through the cell water flow passages, and thereafter circulating that  
14       water through the water flow passages to provide humidification for the cells, and,  
15       (b) at a stack operating temperature above 0° C, initiating and maintaining the  
16       circulation of antifreeze through the stack cooler to prevent the operating  
17       temperature of the stack from increasing beyond a preselected temperature during  
18       the period of operation of the stack prior to said step of circulating the water, said  
19       preselected temperature being selected to prevent the cells from drying out during  
20       said period of operation, and (c) allowing the stack operating temperature to  
21       increase above that preselected temperature after water circulation through the  
22       water flow passages has begun, and (d) shutting down the stack and, upon  
23       shutdown, draining liquid water from the cell water flow passages before it  
24       freezes.

- 1 23. (New) The method according to claim 22, wherein the stack operating  
2 temperature is allowed to increase to said preselected temperature before  
3 antifreeze circulation is initiated, and the antifreeze circulation maintains the stack  
4 operating temperature at said preselected temperature until water circulation  
5 through the water flow passages has begun.
- 1 24. (New) The method according to claim 22, wherein the preselected temperature is  
2 no more than about 40°C.
- 1 25. (New) The method according to claim 22, wherein the preselected temperature is  
2 between 30 °C and 40°C.
- 1 26. (New) The method according to claim 23, wherein said preselected temperature is  
2 between 30 °C and 40°C.
- 1 27. (New) The method according to claim 22, wherein the water circulation system  
2 includes a water accumulator, wherein upon start-up of the stack the accumulator  
3 has frozen water therein, and operation of the stack after startup is used to melt  
4 frozen water within the accumulator.
- 1 28. (New) The method for operating a fuel cell system under freezing conditions, the  
2 system including a stack of PEM fuel cells including at least one cooler for  
3 carrying antifreeze through the stack to remove heat, the fuel cell system further  
4 including a water circulation system including an accumulator that is used for  
5 holding liquid water to be circulated through water flow passages passing through  
6 each cell, wherein, at the time of start-up the accumulator and water flow  
7 passages has no water therein, and there is insufficient liquid water within the  
8 water circulation system to enable the circulation of water through the water flow  
9 passages, the method for operating the fuel cell system including (a) starting up  
10 and operating the stack by introducing non-humidified reactants into the cells and  
11 connecting a load across the stack to generate heat to increase the stack  
12 temperature to a preselected temperature above 0°C and thereby melt any frozen  
13 water within the stack, and (b) at a stack operating temperature between 0° C and  
14 the said preselected temperature, initiating and maintaining the circulation of  
15 antifreeze through the stack cooler to prevent the operating temperature of the  
16 stack from increasing beyond said preselected temperature throughout operation

17 of the stack, said preselected temperature being selected to prevent the cells from  
18 drying out throughout operation of the stack and, (c) preventing the circulation of  
19 water through the water flow passages throughout operation of the stack and  
20 allowing water produced by the stack to accumulate within the water flow  
21 passages during operation, and (d) shutting down the stack and, upon shutdown,  
22 draining liquid water from the cell water flow passages before it freezes.

1 29. (New) The method according to claim 28, wherein said preselected temperature is  
2 no greater than 40° C.

1 30. (New) The method according to claim 29, wherein in step (b) antifreeze  
2 circulation is not initiated until the operating temperature of the stack is at least  
3 10°C.

28 circulating that water through the water flow passages to provide  
29 humidification for the cells, and, (b) at a stack operating temperature above 0°  
30 C, initiating and maintaining the circulation of antifreeze through the stack  
31 cooler to prevent the operating temperature of the stack from increasing  
32 beyond a preselected temperature during the period of operation of the stack  
33 prior to said step of circulating the water, said preselected temperature being  
34 selected to prevent the cells from drying out during said period of operation,  
35 and (c) allowing the stack operating temperature to increase above that  
36 preselected temperature after water circulation through the water flow  
37 passages has begun, and (d) shutting down the stack and, upon shutdown,  
38 draining liquid water from the cell water flow passages before it freezes.

1 23. The method according to claim 22, wherein the stack operating temperature is  
2 allowed to increase to said preselected temperature before antifreeze  
3 circulation is initiated, and the antifreeze circulation maintains the stack  
4 operating temperature at said preselected temperature until water circulation  
5 through the water flow passages has begun.

1 24. The method according to claim 22, wherein the preselected temperature is no  
2 more than about 40°C.

1 25. The method according to claim 22, wherein the preselected temperature is  
2 between 30°C and 40°C.

1 26. The method according to claim 23, wherein said preselected temperature is  
2 between 30°C and 40°C.

1 27. The method according to claim 22, wherein the water circulation system  
2 includes a water accumulator, wherein upon start-up of the stack the  
3 accumulator has frozen water therein, and operation of the stack after startup is  
4 used to melt frozen water within the accumulator.

1 28. The method for operating a fuel cell system under freezing conditions, the  
2 system including a stack of PEM fuel cells including at least one cooler for  
3 carrying antifreeze through the stack to remove heat, the fuel cell system  
4 further including a water circulation system including an accumulator that is  
5 used for holding liquid water to be circulated through water flow passages  
6 passing through each cell, wherein, at the time of start-up the accumulator and  
7 water flow passages has no water therein, and there is insufficient liquid water

8 within the water circulation system to enable the circulation of water through  
9 the water flow passages, the method for operating the fuel cell system  
10 including (a) starting up and operating the stack by introducing non-  
11 humidified reactants into the cells and connecting a load across the stack to  
12 generate heat to increase the stack temperature to a preselected temperature  
13 above 0°C and thereby melt any frozen water within the stack, and (b) at a  
14 stack operating temperature between 0°C and the said preselected temperature,  
15 initiating and maintaining the circulation of antifreeze through the stack cooler  
16 to prevent the operating temperature of the stack from increasing beyond said  
17 preselected temperature throughout operation of the stack, said preselected  
18 temperature being selected to prevent the cells from drying out throughout  
19 operation of the stack and, (c) preventing the circulation of water through the  
20 water flow passages throughout operation of the stack and allowing water  
21 produced by the stack to accumulate within the water flow passages during  
22 operation, and (d) shutting down the stack and, upon shutdown, draining liquid  
23 water from the cell water flow passages before it freezes.

1 29. The method according to claim 28, wherein said preselected temperature is no  
2 greater than 40°C.

1 30. The method according to claim 29, wherein in step (b) antifreeze circulation is  
2 not initiated until the operating temperature of the stack is at least 10°C.